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Outline

- Motivation and discussion of the issues
- Example #I: Z+jets and 'giant K-factors'
- Example #2: high invariant mass Drell-Yan pairs and electrowek Sudakov logarithms
- Example #3: Mixed QCD-EW corrections to Higgs production

Goals of the LHC program



• We all know that QCD plays a crucial role in all stages of this program, but what about EW corrections?

Violating the conventional wisdom

- Simple rule of thumb: $\alpha_s \sim 0.1$, $\alpha_{EW} \sim 0.01$, so EW_{NLO} $\sim QCD_{NNLO}$
- Not always an accurate picture, particularly in certain PS regions







Kinematic-dependent corrections that can mimic such effects as contact interactions (from T. Le Compte)

SUSY searches at the LHC

• A standard search channel is missing energy plus 2-4 jets





- Search for in H_T =sum of jet p_T 's and missing E_T
- Major background from jets plus $Z \rightarrow vv$

Giant K-factors



Rubin, Salam, Sapeta 2010

- Enormous dependence of correction on observable!
- Need EW corrections to understand

Mixing of QCD and EW corrections



• Leading-order Feynman diagrams for Z+jet



- •At NLO the following diagram appears
- Can think of as EW correction to dijet production
- Can have the Z soft+collinear to quarks: $ln^2(H_T/M_Z)$
- Observables such as p_{TZ} don't allow soft/collinear Z's in the high p_T region, removing the enhancement

Solutions

• How should this process be simulated to account for such corrections?



• Matched samples naturally include the appropriate diagrams to get the kinematics correct in the tails

• Experimental cuts can remove the dangerous phase-space region:

	Α	С	D	L
Number of jets	≥ 2	≥ 3	≥ 3	≥ 3
Leading jet p_T [GeV]	> 120	> 120	> 120	> 60
Other jet(s) p_T [GeV]	> 40	> 40	> 40	> 30
$\Delta \phi(\vec{p}_T^{\text{miss}}, j_{1,2,3})$	> 0.4	> 0.4	> 0.4	> 0.2
$m_{\rm eff}$ [GeV]	> 500	> 500	> 1000	> 500
$E_T^{\rm miss}/m_{\rm eff}$	> 0.3	> 0.25	> 0.25	> 0.25
Number of leptons	= 0	= 0	= 0	= 1
Lepton p_T [GeV]	_	_	_	> 20
$m_T [\text{GeV}]$	_	_	_	> 100
ATLAS $\sigma \times Acc$ [pb]	< 1.3	< 1.1	< 0.11	< 0.138

LeCompte, Martin 2011

Interplay of QCD and EW corrections in LHC Physics

Mimicking a contact interaction

• If new physics can't be directly produced at LHC, can still observe at high invariant mass/transverse momentum via contact interactions



Electroweak Sudakov logarithms

- Such EW Sudakov logarithms have been extensively studied (Denner, Pozzorini et al.; Kuhn, Kulesza et al.; Manohar et al.; etc.); two-loop EW Sudakovs known, resummation studied in standard QCD and SCET
- •Unlike in QCD, these double logarithms normally don't cancel



- Real-radiation diagrams (emission of W,
 Z) aren't usually included in observable
 since they can be distinguished
- This generically leads to large negative corrections from virtual graphs
- Often cancel QCD corrections in distribution tails

Including weak-boson emission

• Can partially ameliorate the effect by including emission of W, Z in observable definition



U. Baur 2006

Mixing of QCD and EW corrections

Knowledge of the signal shape and normalisation is crucial in the search for new physics

A generic problem at the LHC:How do we treat mixed QCD-EW corrections? do we add the two corrections or do we multiply them (factorisation)

Assuming one or the other makes a difference in the cross section.



Mixing of QCD and EW corrections

$gg \rightarrow H$ as an example

- Adding QCD and EW corrections increases total cross section by 2%
- Multiplying them assuming complete factorisation of QCD and EW corrections increases the cross section by up to 9%

- Figuring out the right way of dealing with them requires explicit calculation



Anastasiou, R. B., Petriello 2009

- For this process the result of the explicit calculation was consistent with the complete factorisation assumption, ie. QCDxEW

Conclusions

 Preparing for the flood of LHC data requires a good understanding of QCD and EW effects on the signal and background

• EW corrections can be much larger than naively expected, need to take them into account in regions of phase space with large kinematics

• Mixed QCD-EW effects are important in precision analysis